Senior Thesis

A Comparison of Beachrock and Sand, San Salvador Island, Bahamas

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by
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Approved by:

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Contents

Abstract

Carbonate sand and beachrock are common deposits on the beaches of San Salvador Island, Bahamas. The constituents found in the sands and beachrock are the same. Cementation of beachrock occurs in the intertidal zone. The type of cement present in the beachrock indicates cementation in the marine-meteoric mixing zone.

Acknowledgements

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Introduction

San Salvador Island, located at 24 N 74 30'W on the eastern edge of the Bahamas platform, is five miles wide and ten miles long. The Bahamas platform is made up of a sequence of Jurassic, Cretaceous, and Cenozoic carbonates and evaporites. A shallow shelf surrounds the island of San Salvador (Gerace, 1983).

The shoreline is composed of sandy beaches with carbonate sands between headlands of eroded eolianite. Beach ridges and cemented carbonate beach sand, known as beachrock, are common features on these beaches. Beachrock is currently forming in the intertidal zone on many of these beaches. Two ages of beachrock are recognized on San Salvador. Some of the older beachrock is covered with calcrete crust.

Several theories have been proposed to explain the origin of beachrock cement. These include precipitation from sea water, precipitation at the water table, and precipitation from mixed meteoric and marine waters. A petrographic analysis of San Salvador beachrock and sand was conducted to identify and compare constituents and cements in order to determine the origin of the beachrock.

Methods

Samples of beachrock and sand were taken from eight localities on San Salvador Island. These samples were used to make standard thin sections for petrographic analysis. Grain mounts of the sand samples were made by setting the grains in epoxy resin. Most of the beachrock samples were poorly cemented and required impregnation. This was done by injection of epoxy resin under high pressure. Petrographic analysis was done to determine the types and percentages of constituents present in rock and sand samples, and type of cementation occurring in the rock samples.

Beachrock and Sand on San Salvador Island

The beachrock on San Salvador Island is differentiated between older and younger beachrock on the basis of outcrop appearance and occurrence. Modern beachrock is found in the intertidal zone, where it is currently forming. Modern beachrock appears in outcrop as large, flat slabs of rock dipping shallowly seaward. These are up to .5 m thick and are jointed perpendicular and parallel to the shoreline (Beier, 1985). Color ranges from pale yellow to brown. Bioerosion by gastropods, chitons, and algae occurs at several sites. Older beachrock is found inland of the intertidal zone. This would indicate that sea level was higher at the time of formation, as the shoreline moves seaward with a lowering of sea level (Beier, 1985). Beachrock may also form at higher levels on the beach from sand piled up against the shoreline as sand is moved around by longterm changes in the storm track. The older beachrock is weathered and covered in places by a calcrete crust.

Calcrete crusts are formed during periods of subaerial exposure. Inclusion of Recent artifacts at some sites indicates Recent cementation. In some cases modern artifacts have been washed into cracks between blocks of older beachrock. These cracks are in turn filled with sand that quickly becomes cemented, giving the impression that modern artifacts occur in old beachrock. Sand on San Salvador Island ranges from fine grained to coarse grained, depending on the beach environment at each site. The sandy beaches dip shallowly seaward.

Grapestones and ooids, common in the beachrock and sand deposits on San Salvador Island, are not known to be forming presently. Grapestones are clumps of various kinds of carbonate sand grains cemented together to form irregularly shaped grains. According to Bathurst (1971), grapestones form in shallow water with little turbulence, where they may remain undisturbed until they can be cemented; the cement is believed to be produced by boring algae. This study suggests that some of these may be lithoclasts eroded from beachrock. Ooids are grains composed of concentric lamellae formed around a nucleus. They typically form in high energy shoaling areas. The ooids must have formed at a time when sea level was at the appropriate level for shoaling areas to develop on the shelf surrounding San Salvador Island. Grapestones and ooids are also found in the eolianites.

Discussion of Beachrock Cementation Models

Several theories have been proposed to explain the origin of beachrock cement. Ginsburg (1953) supported the theory that beachrock cement is precipitated from sea water based on his studies of beachrock in South Florida. He concluded that marine beachrock is produced by precipitation of interstitial aragonite in the intertidal zone. This is dependent on supersaturation of calcium carbonate in sea water, temperature, and the rate and degree of beach drainage (Ginsburg, 1953). Ginsburg describes this type of cement in thin section as a fringe of acicular crystals of calcium carbonate lying perpendicular to the grain edges. Supersaturated sea water perculates through the beach sands, which forms an intergranular film throughout the sand. During low tide and increased temperatures, aragonite precipitates to form a cement (Ginsburg, 1953).

Stoddart and Cann (1965) described the precipitation of beachrock at the water table, based on work done by R. J. Russell and others. According to Russell (1963), beachrock is cemented by calcite precipitated from ground water. Cementation occurs at the water table beneath the beach. This requires that the ground water have a high calcium carbonate content (Russell, 1963). Although the ground water has a high calcium carbonate content, it is not supersaturated. Unlike supersaturated sea water, it is capable of dissolving calcareous material in the sands (Stoddart and Cann, 1965). Thin sections of cement which have formed at the water table show the cement to be composed of elongated, platy crystals.

Moore (1973) suggested that mixing of meteoric and marine waters in the intertidal zone produces cementation of beachrock, based on his work on Grand Cayman, West Indies. Moore determined through chemical composition and isotopic analysis that marine and meteoric waters mix to form the cement in beachrock. Using thin section analysis, Moore described this type of cement as having acicular, bladed, and equant crystals. Observations by Beier (1985) on San Salvador Island support this theory.

Thin Section Descriptions

Seven of the collected samples were chosen for petrographic analysis: GH-1, GH-2, GH-3, SR-1, SR-2, FB-1, and OP-1. Point counts of three hundred points were used to determine relative amounts of each type of grain in each sample. These are listed in Table 1 and shown graphically in Figure 2. The following is a description of these samples in thin section.

GH-1: Older Beachrock, Grahams Harbor, San Salvador Island

Sample GH-1 is a sample of the older beachrock on San Salvador Island. It was collected at Grahams Harbor on the north side of the island. The older beachrock consists of grapestones, mollusk fragments, foraminifera, halimeda, coral, ooids and peloids, and echinoids. Many of the grains are highly micritized. The grains are held together by a blocky, equant cement. The rock is poorly cemented. The age of this rock is unknown, but it may be related to the sea level high approximately 5,000 years ago.

GH-3: Younger Beachrock, Grahams Harbor, San Salvador Island

Sample GH-3 is a sample of the younger beachrock from Grahams Harbor. The grains in the younger beachrock are similar to those observed in the older beachrock. These include grapestones, mollusk fragments, foraminifera, halimeda, coral, ooids and peloids, and echinoids. Many of the grains are micritized. The grains are cemented together moderately well. The cement is fibrous and acicular, unlike the blocky cement of the older beachrock.

GH-2: Sand, Grahams Harbor, San Salvador Island

Sample GH-2 is sand collected at Grahams Harbor. It is similar in content to the beachrock. The constituents found in the sand are grapestones, mollusk fragments, foraminifera, halimeda, coral, red algae, ooids and peloids, and echinoids. Some of the grains are micritized. Some of the grains have a rim of blocky, equant cement, although the grains are not cemented together. This indicates that some of the sand is being derived from beachrock or other older rocks.

SR-1: Younger Beachrock, Fernandez Bay, San Salvador Island

SR-1 is a sample of younger beachrock collected from Fernandez Bay on the west side of the island. This beachrock consists of grapestones, mollusk fragments, foraminifera, halimeda, coral, ooids and peloids, and red algae. Some of the grains have been micritized. The cement in SR-1 is fibrous, acicular cement. The rock is moderately well cemented.

SR-2: Sand, Fernandez Bay, San Salvador Island

This sand was collected at Fernandez Bay. Constituents in SR-2 are similar to the constituents of the beachrock. Grapestones, mollusk fragments, foraminifera, halimeda, coral, ooids and peloids, red algae, and echinoids are the types of grains present. Few of the grains are micritized. A fibrous, acicular cement forms a rim around a few grains. Other grains have rims of blocky, equant cement. This indicates that some of the sand is derived from beachrock or other older rock.

FB-1: Younger Beachrock, French Bay, San Salvador Island

FB-1 is a sample of younger beachrock from French Bay on the south side of San Salvador Island. The grains consist of grapestones, mollusk fragments, foraminifera, halimeda, coral, ooids and peloids, red algae, and echinoids. Little micritization has occurred. These grains are well cemented with a fibrous, acicular cement, similar to the cement seen in samples SR-1 and GH-3.

OP-1: Older Beachrock, Monument Beach, San Salvador Island

Sample OP-1 is older beachrock collected near the Columbus Monument on the west side of the island. It contains grains of grapestones, mollusk fragments, foraminifera, halimeda, coral, ooids, and peloids. Many of the grains show micritization. The rock is poorly cemented, and has a blocky, equant cement similar to the cement in the older beachrock, GH-1.

Discussion

Similar constituents are found in samples of beachrock and sand from the same locality on San Salvador Island. Sand samples have grains with rims of cement which appear to be derived from their corresponding beachrocks. This suggests that the beach-rock is being reworked into sand by the process of erosion. The present sand deposits may eventually become cemented to become beachrock as well. Point count analysis shows that beachrock contains fewer mollusks than the sand. This may be due to dissolution of aragonitic shells during diagenesis and cementation of the beachrock.

Beachrock of similar age from different localities have similar cements. The cements in older beachrocks are blocky and equant, while cements in younger beachrocks are fibrous and acicular, suggesting that neomorphism may occur with exposure to meteoric water. Cementation occurs in the intertidal zone, as is evidenced by the current formation of modern beachrock. This suggests that cementation occurs by the mixing of meteoric and marine waters in the intertidal zone. This is consistent with the findings of Beier (1985).

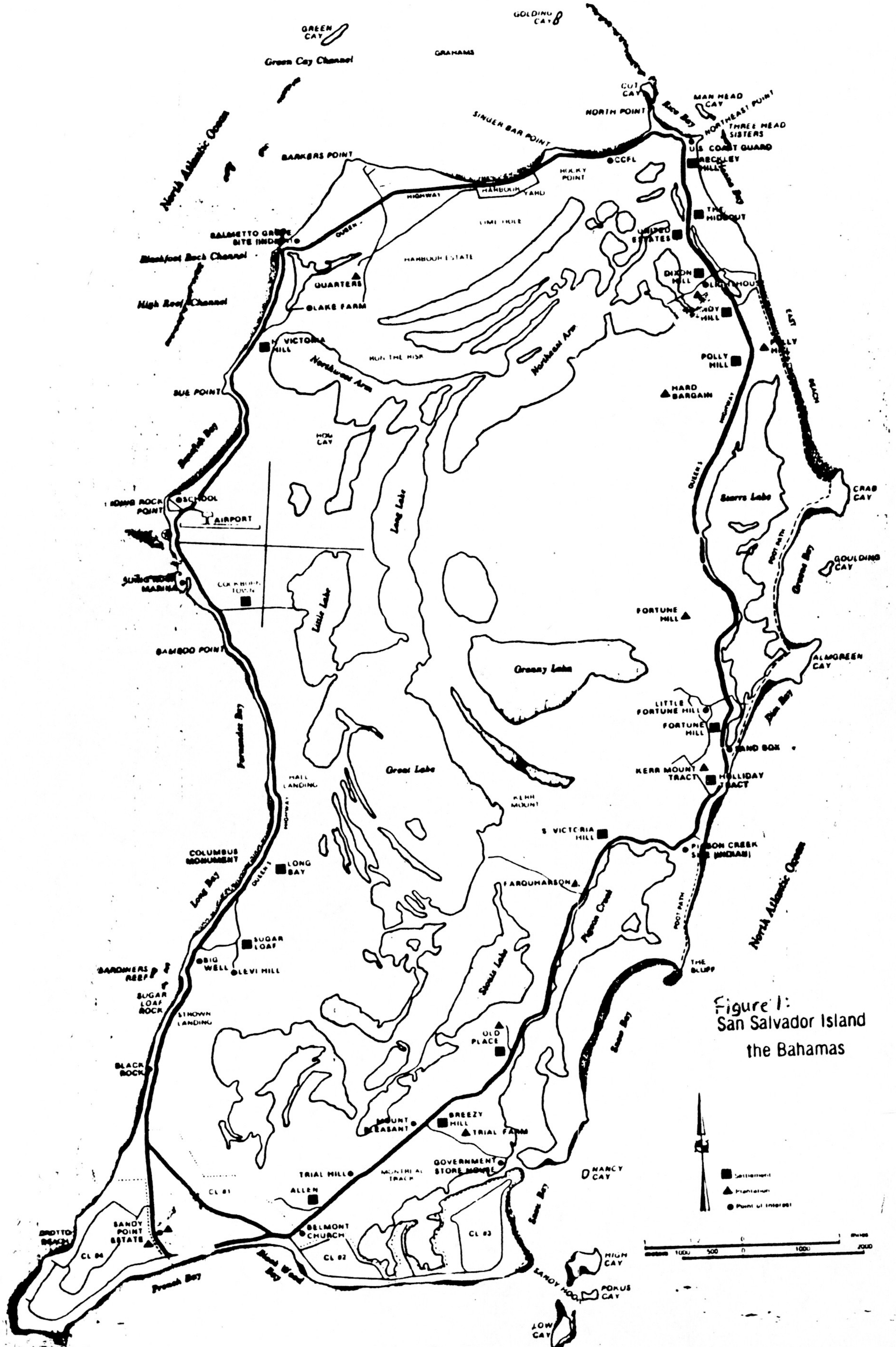


Figure 1:
San Salvador Island
the Bahamas

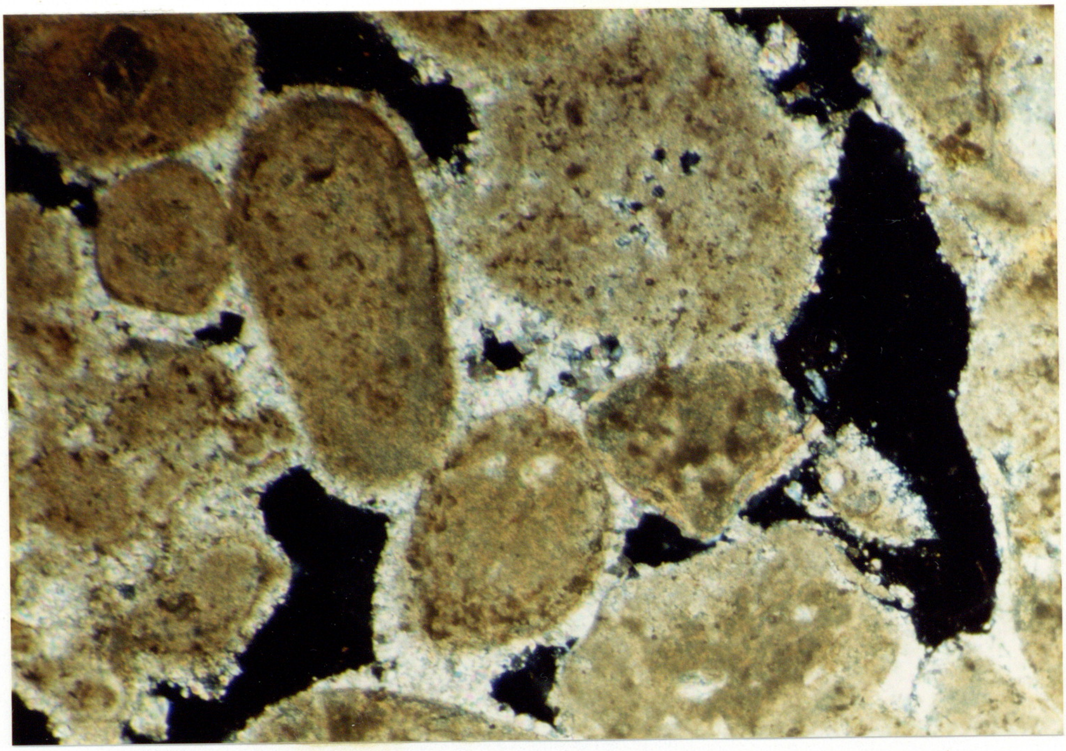
Table 1: Constituents Determined by Point Count Analysis

Samples:	**GH-2**	**GH-3**	**GH-1**	**SR-2**	**SR-1**	**FB-1**	**OP-1**
CONSTITUENTS:							
GRAPESTONE	140	126	140	142	116	96	93
MOLLUSK	106	62	42	89	70	58	105
OOIDS & PELLOIDS	27	58	60	35	31	21	63
CORAL	2	4	3	2	3	17	4
FORAMS	12	7	13	13	9	33	3
HALIMEDA	6	14	8	14	24	41	14
RED ALGAE	1	0	0	2	3	3	0
ECHINOIDS	2	1	1	1	0	2	2
MISCELLANEOUS	4	28	33	2	44	29	16
TOTAL	300	300	300	300	300	300	300

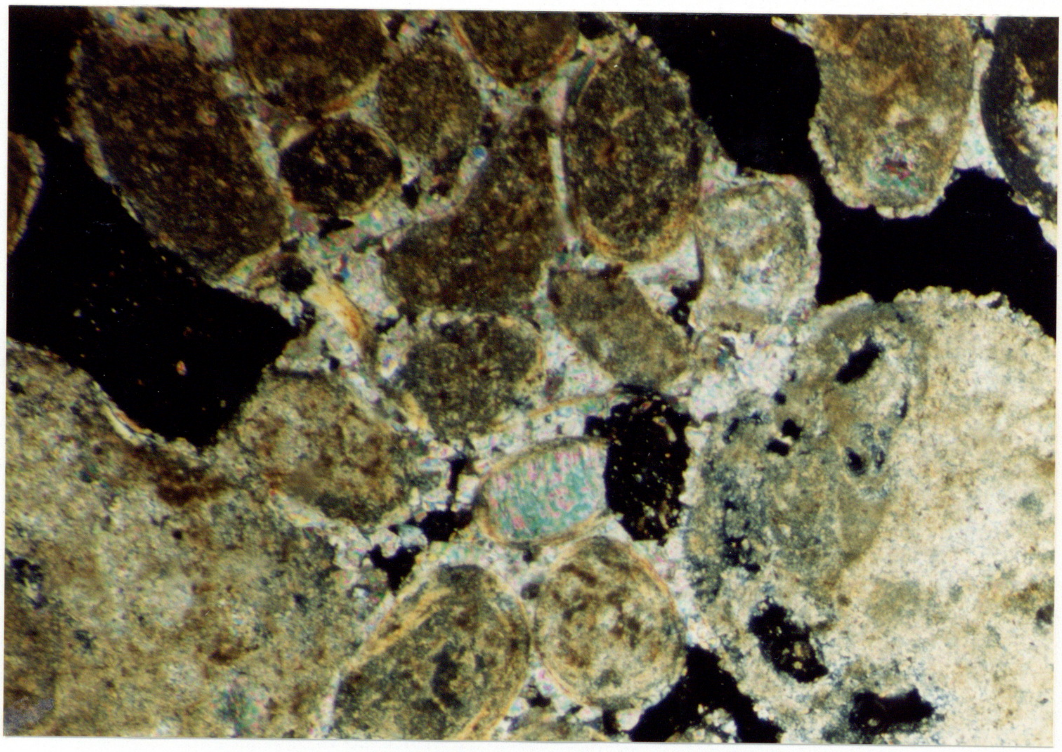
Figure 2: Older Beachrock, Barkers Point, San Salvador Island

Figure 3: Younger Beachrock, Fernandez Bay, San Salvador Island

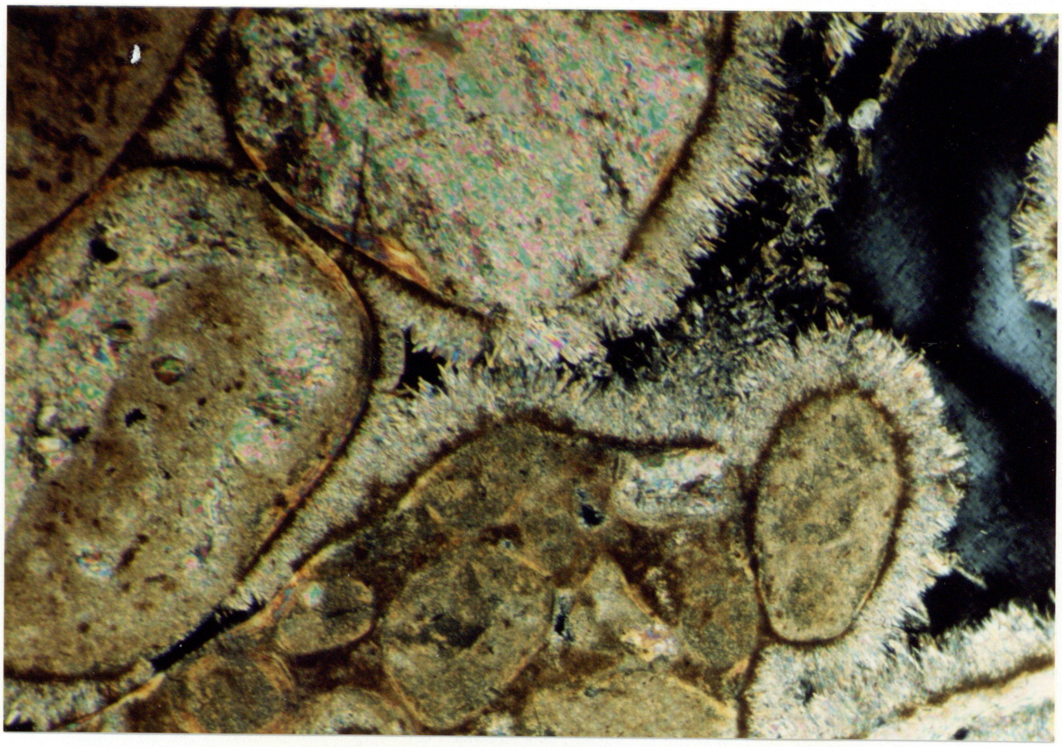
Figure 4: Photomicrographs of Older Beachrock, Grahams Harbor, San Salvador Island



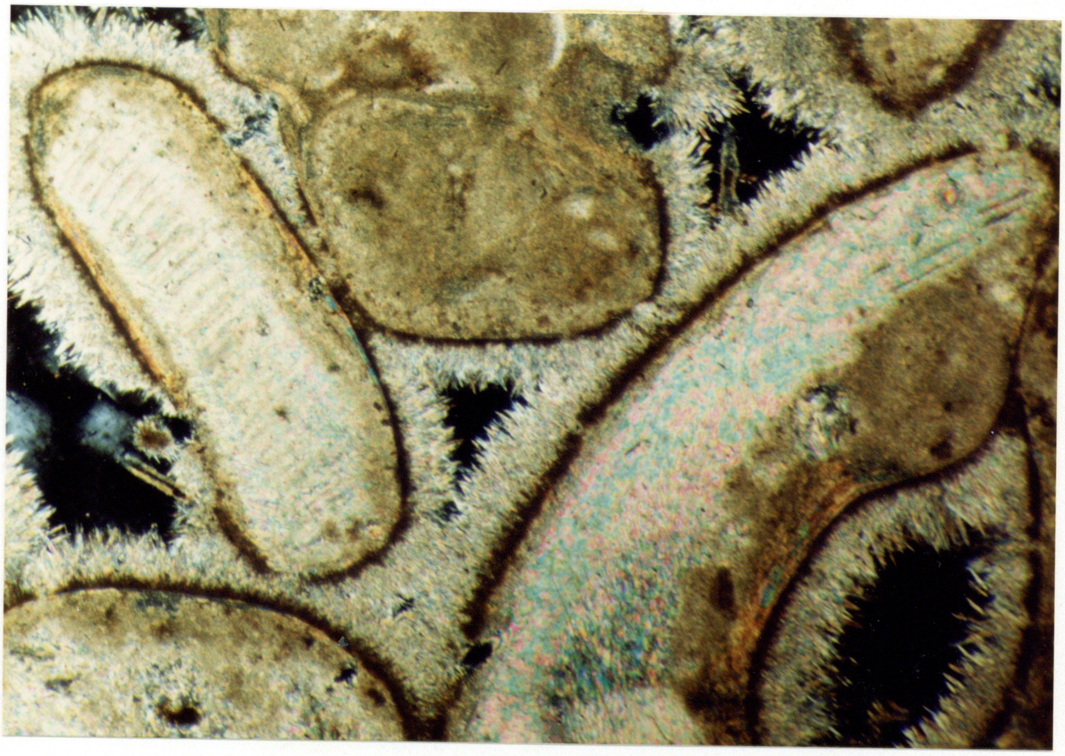
Blocky, equant cement between ooid and peloid grains. (Magnification: 100x).



Blocky, equant cement between mollusk and ooid grains. Grains show micritization. (Magnification: 100x).



Fibrous cement between grapestone and mollusk grains.
(Magnification: 100x).



Fibrous cement between mollusk grains. Grapestone also present.
(Magnification: 100x).

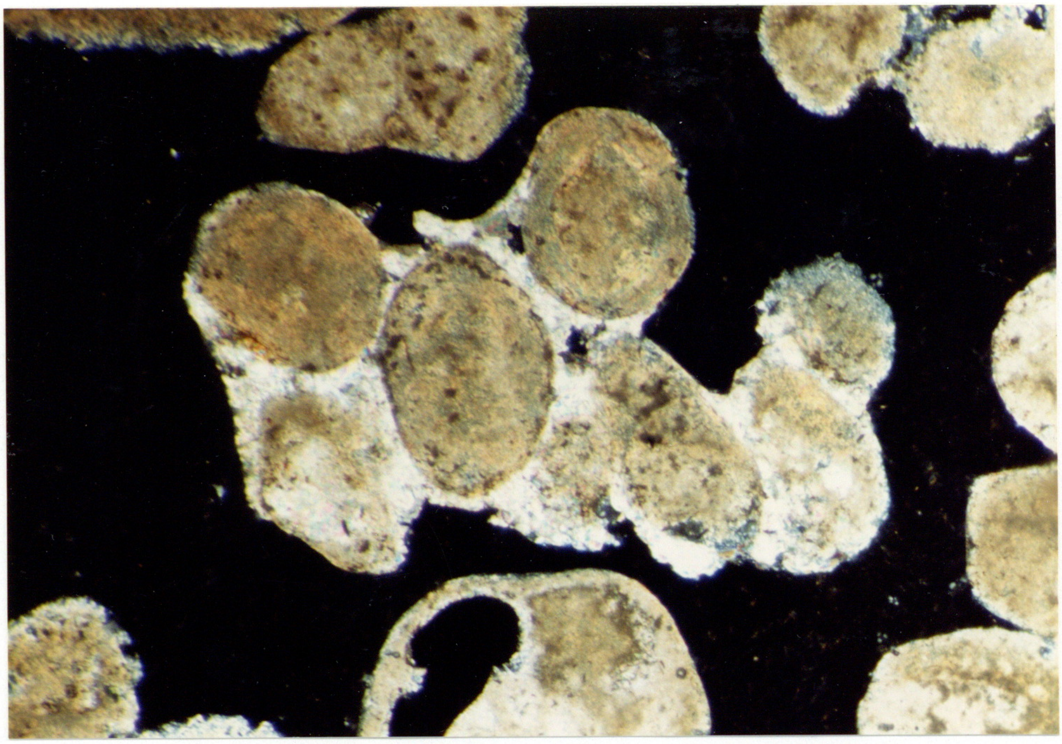


Figure 6: Photomicrograph showing grapestone in beach sand from Grahams Harbor, San Salvador Island. (Magnification: 100x).

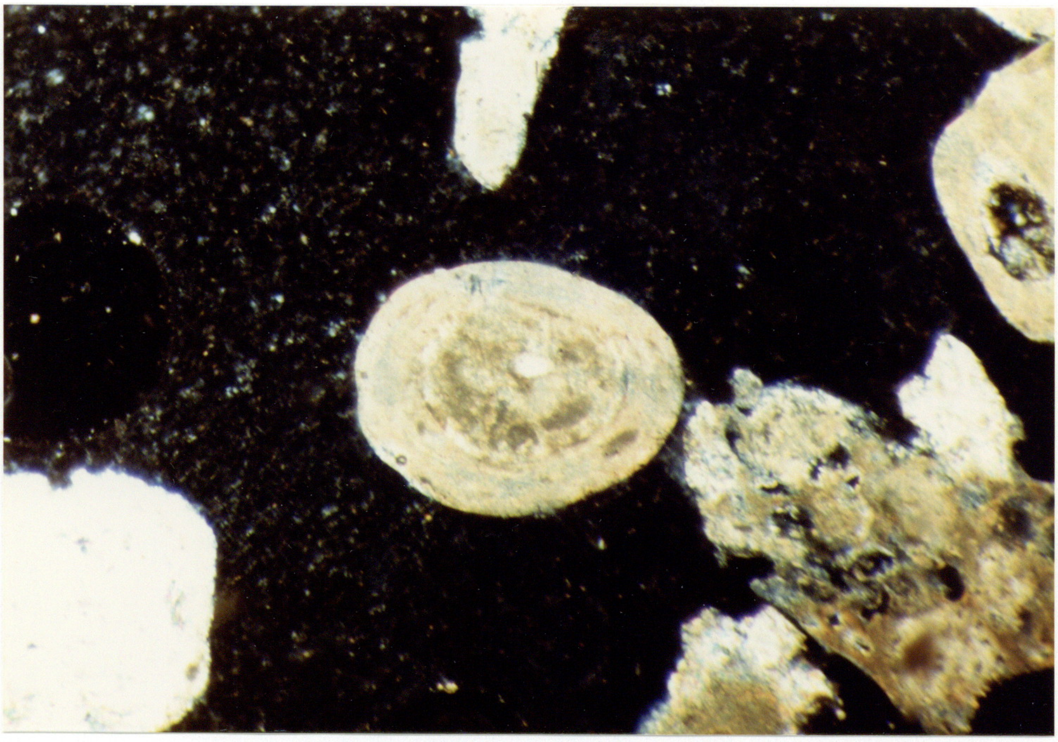
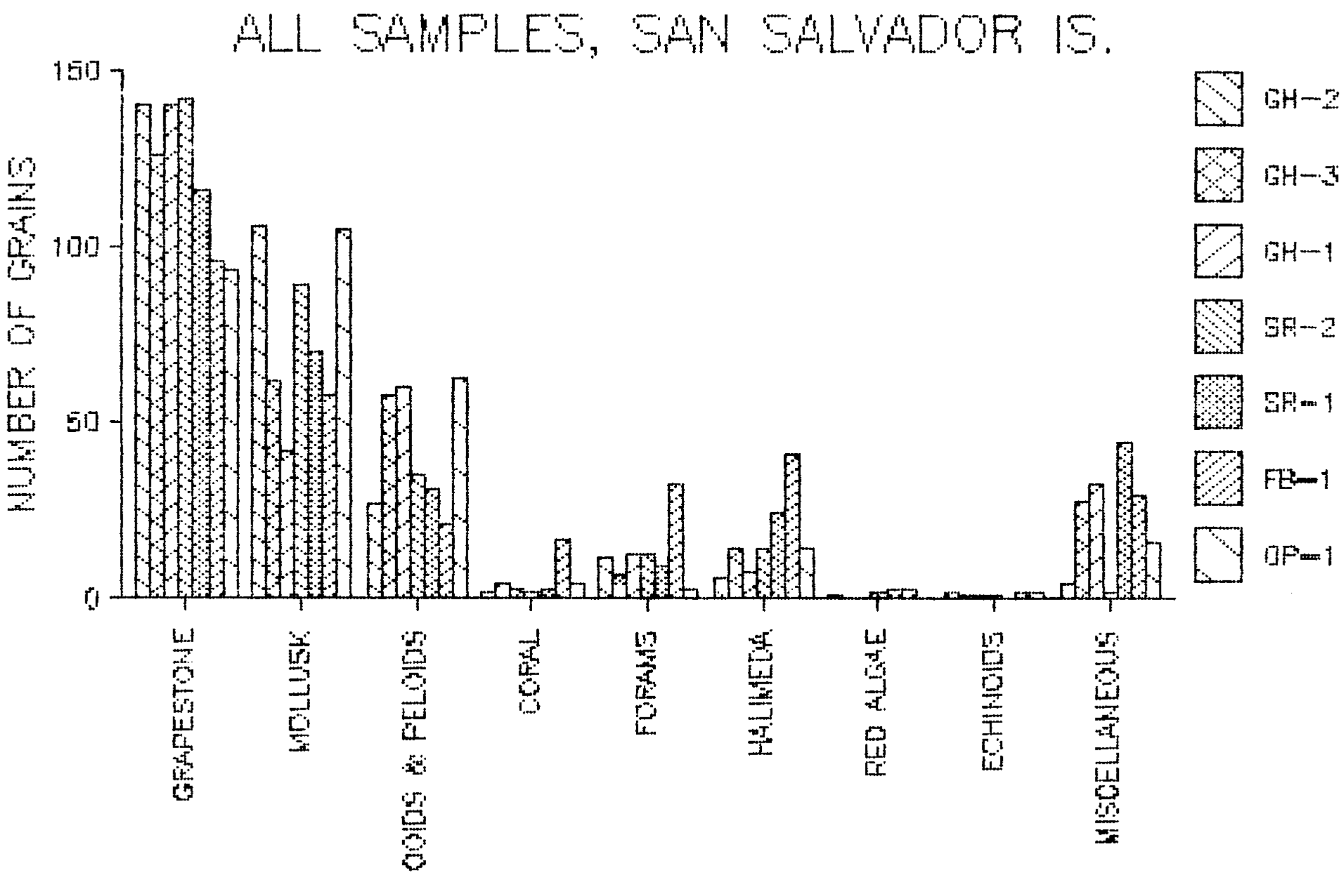
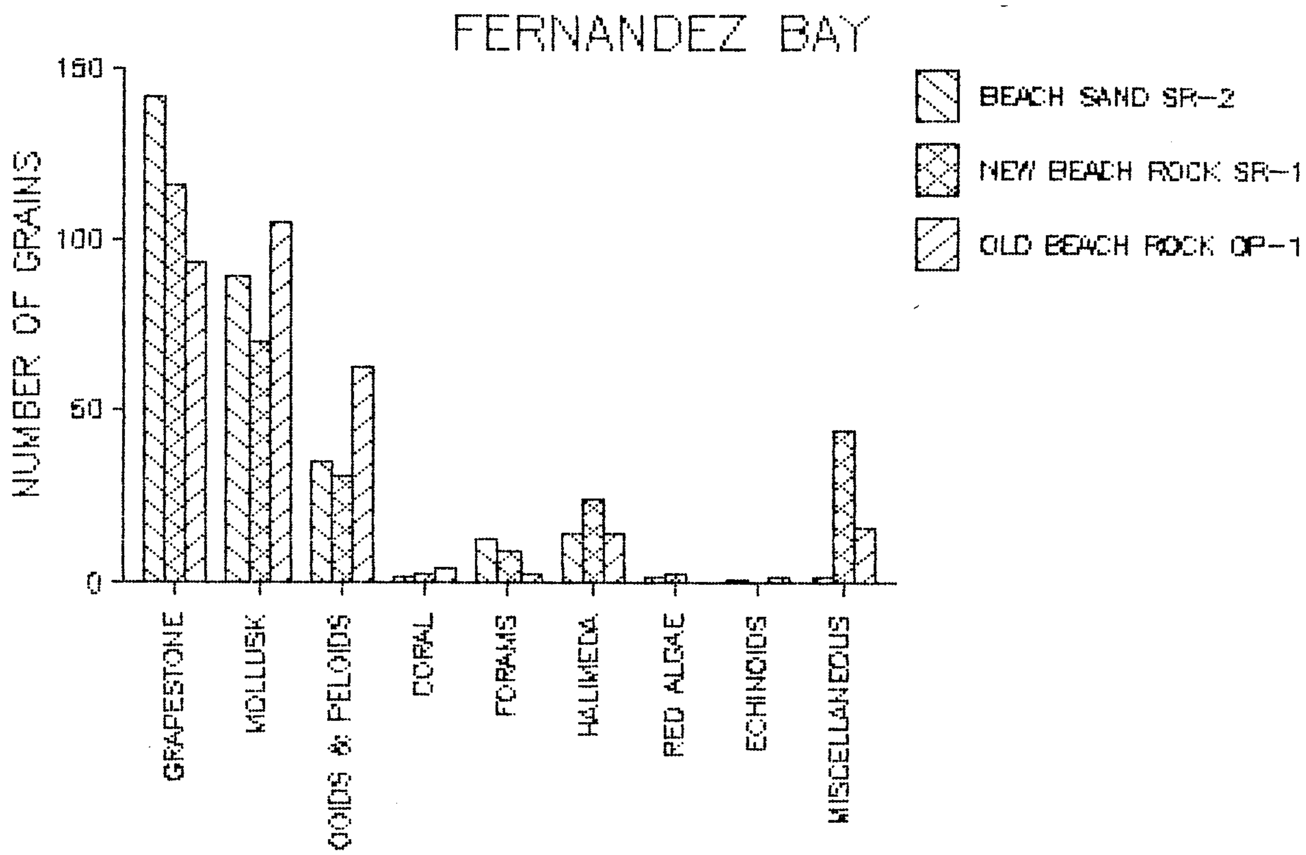


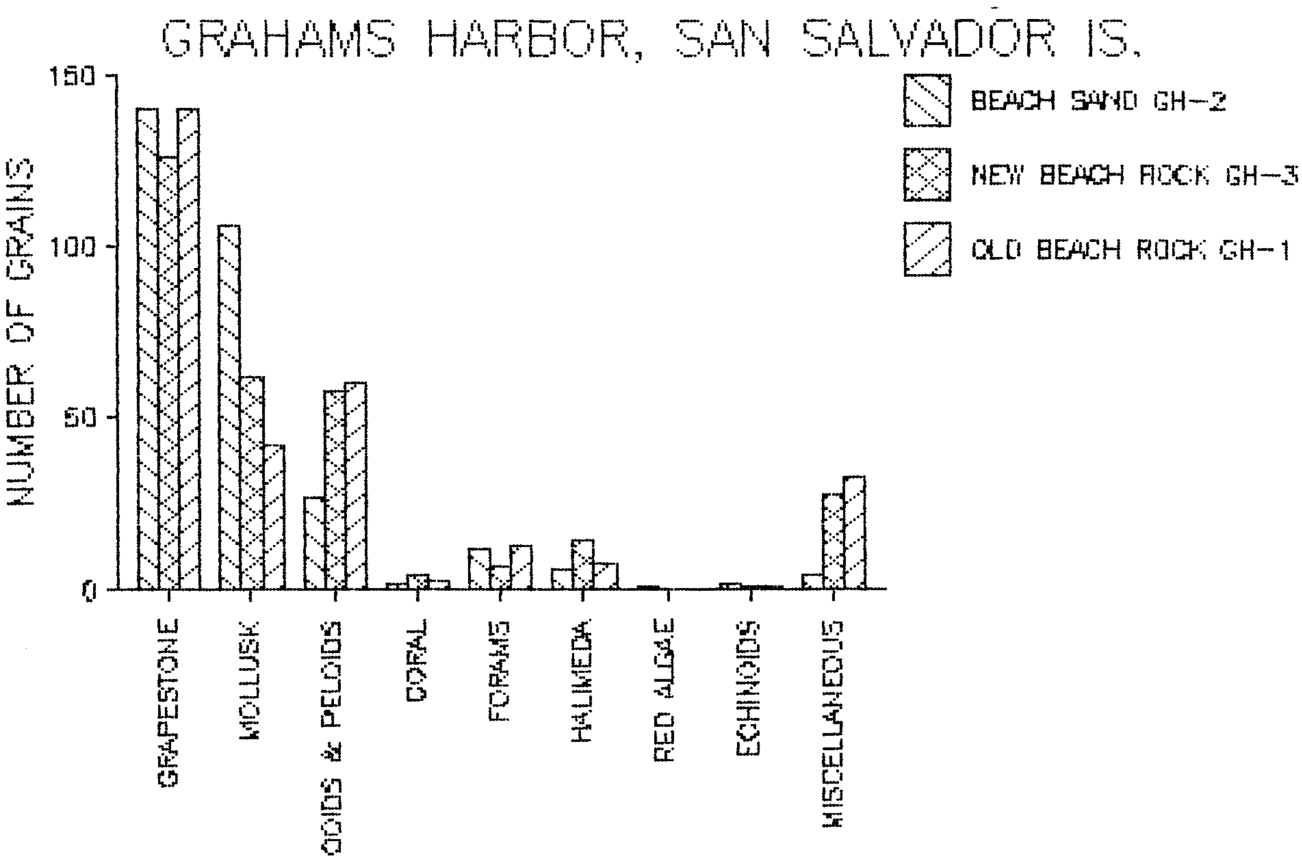
Figure 7: Photomicrograph showing ooid in beach sand from Grahams Harbor, San Salvador Island. (Magnification: 100x).



ALL SAMPLES, SAN SALVADOR IS.
NUMBER OF GRAINS
150
100
50
0
GRAPESTONE
MOLLUSK
OOIDS & PELOIDS
CORAL
FORAMS
HALIMEDA
RED ALGAE
ECHINOIDS
MISCELLANEOUS
GH-2
GH-3
GH-1
SR-2
SR-1
FB-1
OP-1



FERNANDEZ BAY
NUMBER OF GRAINS
150
100
50
0
BEACH SAND SR-2
NEW BEACH ROCK SR-1
OLD BEACH ROCK OP-1
GRAPESTONE
MOLLUSK
OOIDS & PELOIDS
CORAL
FORAMS
HALIMEDA
RED ALGAE
ECHINOIDS
MISCELLANEOUS


GRAHAMS HARBOR, SAN SALVADOR IS.
NUMBER OF GRAINS
150
100
50
0
BEACH SAND GH-2
NEW BEACH ROCK GH-3
OLD BEACH ROCK GH-1
GRAPESTONE
MOLLUSK
OOIDS & PELOIDS
CORAL
FORAMS
HALIMEDA
RED ALGAE
ECHINOIDS
MISCELLANEOUS

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